NOTES ON THE LEAD AND ZINC DEPOSITS OF THE MISSISSIPPI VALLEY AND THE ORIGIN OF THE ORES.

THE recent closing down of the silver mines of Colorado and other Western states means not only a lessening of the silver production of the country, but also the shutting off of its greatest source of lead supply. During the past few years over two-thirds of the total yield of domestic lead has been from the argentiferous lead ores of Colorado, Utah, Idaho, Montana and Nevada. Unless operations are resumed in the West, the demand must consequently soon be concentrated upon the deposits of non-argentiferous lead in the Mississippi Valley, which have been in the past the sole important producers. A rise in the price of lead is to be expected as a result, which, in turn, will lead to increase in exploitation and development.

The question naturally arises, therefore, to what extent are these Mississippi Valley deposits to be depended upon for future supply. They have been large and almost constant producers in the past; will they continue to be such in the future? The history of their development, which is in many respects remarkable, lends color to the hope that such will be the case, especially in Missouri. Lead mining was begun in that state as much as 170 years ago, and has continued almost uninterruptedly since. Indeed, the first deposit worked, that of Mine La Motte, has up to this year supplied large quantities of ore, the total value of its product to date being in the neighborhood of $8,000,000. The various bodies of ore have shown signs of exhaustion from time to time, and the industry in the state has waned. About the year 1854 the condition was such that even so competent a judge as Prof. J. D. Whitney[1] ventured the prediction that the supply was nearly exhausted, and that the lead mining of Missouri was a thing of the past. But ever after such depression, deeper excavations have developed new bodies of untouched ores, wider explo-

[1] Metallic wealth of the United States, p. 419.

rations have revealed new fields, or improvements in mining and metallurgical methods have made previously rejected ores available. Along with this, the utilization of the associated zinc ores has led to the opening up of deposits which previously lay untouched, enclosing often unexpected quantities of lead. During the past twenty years Missouri's production has reached large proportions. The total amount mined during this period is fully twice that of the preceding 150 years—a startling refutation of the early adverse predictions. The output during recent years has been only second to Colorado's, and this year will probably be first among the states of the Union; the total amount produced to date probably equals, if it does not exceed, that of any other state.

Similar in some respects are the facts of zinc production. The mining of these ores does not, however, date much more than twenty years back, and hence the industry has not suffered much from the vicissitudes of the early mining. The production grew rapidly from its beginning, and now ranks first in the country. The total output up to the present time is nearly equal to the combined total productions to date of all other states in the Union.

The showing for the Upper Mississippi or Wisconsin zinc and lead area is not quite so good. Mining there dates hardly more than 100 years back, and it was not on an active basis before 1823. The period of maximum work was about the year 1845, and soon after this time Prof. Whitney seems to have been of the opinion that its prospects were better than Missouri's, though he predicted a continued decline. The utilization of the zinc ores began about 1860, which tended to sustain the mining industry and the production of lead, though on a much reduced scale. In the early seventies the production of zinc was quite large and something like a resuscitation of mining took place. During the past thirteen years there has, however, been a general decline, and recently little mining has been in progress. At the time of maximum activity, in 1845, the production of lead was about 27,000 tons per annum; but that of zinc ore, in 1872, was only 22,000 tons. The total amount of lead produced to date is prob-

ably something over 650,000 tons, and of zinc ore only about 250,000 tons.

With such facts in mind it is of interest to note that the deposits to which they relate are the subjects of renewed study at the present time, and the prospect of increased demands upon them, above referred to, makes the revival of the discussions of their origin and mode of deposition most timely.

At the recent meeting of the American Institute of Mining Engineers, held as part of the International Engineering Congress, three papers were presented bearing, in whole or in part, upon the ores of the Mississippi Valley, and another, on the Bertha zinc mine of Virginia, described an ore body belonging essentially to the same class. These papers were by Messrs. F. Posepny[1], W. P. Jenney[2], S. F. Emmons[3], W. P. Blake[4], and W. H. Case[5], respectively.

The first of these papers, by Professor Posepny, is a description and discussion of ore deposits in general, in which he advocates their deep-seated origin through the medium of hot solutions derived from great depths. The second paper, by Dr. Jenney, is an exposition of his views concerning the origin of the Mississippi Valley ores, derived from his recent studies in the region. He repudiates the explanation of lateral concentration advocated by Whitney and Chamberlin, and reverts to the old ideas of Owen and Percival, that the ores have come from below, thus harmonizing with Posepny. The other three papers are principally descriptive, though Mr. Emmons quotes Dr. Jenney's conclusions as applied to the Mississippi Valley ores.

Posepny's direct reference to the ores here discussed is brief. He marshals few facts from the region itself in support of his theory, but rather argues, in a negative way, that no great obstacles exist there which would prevent its accceptance. Thus,

[1] The Genesis of Ore Deposits.

[2] The Lead and Zinc Deposits of the Mississippi Valley.

[3] Geological Distribution of the Useful Metals in the United States.

[4] The Mineral Deposits of Southwest Wisconsin.

[5] The Bertha Zinc Mine.

as positive evidence in Missouri, he states that while the deposits away from the granite and porphyry "islands" of southeastern Missouri consist chiefly of lead and zinc ores, "other metals, such as copper, cobalt and nickel occur as the Archean foundation rocks are approached." This circumstance, he states, is "an indication that the source of the lead deposits also is to be sought in depth." Whatever may be the value of this "indication," the facts, as stated, do not hold generally, in the opinion of the writer. Professor Posepny reasons, presumably, from observations made at Mine La Motte, where such conditions exist. At other places, however, these changes in composition are not observed as the crystalline rocks are approached. At Bonne Terre copper pyrite was found in the old *upper* workings containing about four per cent. of nickel and cobalt. It does not characterize the deeper ores. At Doe Run, a mine recently opened, work is prosecuted along the old water-worn pre-Cambrian surface of the Archean granites, amid the very conglomerate boulders, and very little copper pyrite with cobalt and nickel is found. Again, at other localities in St. Genevieve, Franklin, Crawford and other counties, copper ores occur remote from any granite or porphyry outcrops, and well above the basal beds of the Cambrian.

In the way of negative evidence, our author, in considering the Wisconsin deposits, seems to think the absence of ores in the great thicknesses of limestones and sandstones which underlie the productive horizons a by no means conclusive fact as opposed to their deep-seated source, and suggests that the solution may have come up through a passage not yet exposed, and even that fault fissures and eruptive dikes exist which have not been discovered. From the fact that he refers in this connection only to Whitney's report of 1862, we conclude that he has not had access to the later and more exhaustive works of Strong and Chamberlin. Perhaps, with the full light conveyed by these reports and accompanying maps, Professor Posepny might have attached more importance to the objections raised. It is difficult to conceive how such a passage for the solutions as he suggests

could possibly exist without its presence having been revealed and its course traced, with all the widespread mining and exploring which has been conducted in this region during the past seventy years. Neither can one see how the solutions could traverse the intervening great thicknesses of water-soaked sandstone without becoming diffused, in great part at least. The failure to find such a passage and the absence of the ores in the beds assumed to have been traversed, though evidence of a negative character is so strong that it becomes of almost positive value in support of the theory of lateral segregation.

Dr. Jenney, in support of his position, recognizes systems of fault fissures in the ore districts of both south-western and south-eastern Missouri, which cross each other in different directions; these, he considers, served as channels for the metal bearing solutions, and the association of the fissures with the ore bodies he adduces as evidence of such derivation. The deposits of the south-western portion of the state occur almost exclusively in the Mississippian or Lower Carboniferous limestone. Cross fissures or fault fissures in the rocks, if they exist, are not very apparent. The strata are undoubtedly very much shattered in certain limited areas, and have been subjected to extensive subterranean erosion and corrosion and great silicification. Of a system of extensive or considerable faults, recent stratigraphic work in this region has, however, revealed nothing.

In the Cambrian limestones of the eastern part of the state the conditions are somewhat different. Crevices and fissures are there plainly developed, and evidence of considerable faulting is indubitable. In Franklin County such vertical crevices have supplied large quantities of ore. In that portion of the southeast to which reference is especially made, however, and which has produced by far the bulk of the lead, the crevices, whether marking faults or not, are of insignificant dimensions, and the experience has been that they contained themselves little or no ore. On the contrary, the great ore masses consist of galena disseminated through a thickness of the country rock, often of fifty feet or more. At Bonne Terre a tract 1300 feet long by 800

feet wide has been mined out of such diffused ore. The crevices which traverse this ore body are frequently almost blind, and can only be detected by the drip of roof water. These are such as occur in almost any massive rock. Further, one of the most important faults in this region, which traverses the country about two miles north of Mine La Motte, with an apparent throw of 300 feet, is entirely unaccompanied by ore, though the adjacent ground has been prospected with the diamond drill. Again, not a single instance can be recalled by the writer, in those mines which work to the very contact with the underlying granite, where faulting crevices extend down into that rock. They possibly do so extend in some instances, but there is no positive evidence adduceable that they then continue ore bearing. Apart from this, however, the association of ore and crevices, of course, does not denote by any means a deep-seated source for the ore. Such crevices generally act both as channels controlling their distribution, and as receptacles for their accumulation whatever the source of the ores. Hence, a disturbed and creviced region, which is in other respects adapted to the reception of ores, will be their most natural habitat. Therefore the explanation of the localization of the deposits based upon such conditions is equally consistent with any of the common theories of ore derivation. The same, it would seem, can be said concerning the observed paragenesis of the minerals and the growth of crystals, in which Dr. Jenney sees additional foundation for his conclusions. If we accept the broader idea of lateral secretion, which does not demand that a mineral shall be derived from the very rock to which it is attached, but recognizes abundant flow along crevices and through porous strata and a consequent free transfer of solutions from place to place, all the phenomena find at least an equally ready explanation. It is argued further, in this paper, as against the lateral secretion theory, that the metallic contents of the country rocks are insufficient to have supplied the ore bodies. The grounds for this statement are only suggested; but, to the best of our knowledge, the fact yet remains to be proven. Due allowance is not made for the many and various ways in

which minute quantities of substances disseminated through vast volumes of rock may be brought together.

In evidence of the post-Carboniferous age of the deposits the statement occurs several times in Dr. Jenney's paper, that the ores occur in the Coal Measures. This, we think, should be made with limitations. They are found in shales of that age in Jasper county, and at a few other localities, but these shales are in isolated patches, which occupy depressions in the older ore-bearing Mississippian rocks. The metallic contents of the coal may, hence, be derived, by some secondary process of transfer, from adjacent ore bodies. In any case, the Coal Measures in the state, as a whole, are practically destitute of these ores, and they can thus hardly be stated to occur in that formation, whether their absence be due to their prior formation or to limitations in their distribution determined by physical causes.

Dr. Jenney seeks further to find support for the hypothesis of the deep-seated origin of the ores through analogy, in stratigraphy and geologic history, with regions of the far West. This attempt does not seem, in our judgment, to be successful. The last pronounced regional disturbance of both the Ouachita and Ozark uplifts was immediately after the Coal Measure period. In Arkansas this was accompanied by great flexing of the strata. There is no evidence in the Ozark uplift of any intense disturbance of post-Cretaceous date, or of the presence, even at great depths, of flows of such igneous rocks as accompanied the uplift and preceded the ore formation of the Rocky Mountains. As already expressed, the Missouri ores cannot be properly considered to occur in the Coal Measures of the state. Did such a profound fissuring take place in post-Cretaceous times as Dr. Jenney's hypothesis requires, we should expect to find it extending into the body of the Coal Measures, accompanied by the ores. At least faulting or other such exhibition of disturbance would be found, which phenomena do not characterize these rocks.

Over and above these considerations affecting the quality of the support of this theory, there still remain the positive obstacles to be disposed of. The almost entire absence of the

precious metals in the Missouri ores is a fact which further weakens the force of any analogy which may exist between their conditions of deposition and those of the Rocky Mountain ores. How are the objections raised by Whitney and Chamberlin, discussed in a previous paragraph, to be met; such as the facts that faults are practically absent from the region; that there is little ore in the underlying Lower Magnesian beds and none in the Potsdam and St. Peter's sandstones; that no deep and continuous crevices like true fissures are found; that no hydrostatic cause is assigned for the ascension of the solutions from great depths. How could the ores be carried across such thick pervious and water-soaked strata as those of the Potsdam and St. Peter's formations?

The generally accepted facts that the deeper-seated rocks are richer in metallic constituents; that subterranean waters are of high temperature and under great pressure, and consequently are powerful solvents; that the relief of pressure and the diminution of temperature accompanying the ascent of such solutions supply an abundant cause for the deposition of their metallic burdens, are all good and enticing general reasons in favor of the adoption of the theory of a deep source for *all* of our metalliferous deposits. Yet, on the other hand, we must recognize that *some* of our ores, notably those of iron and manganese, cannot be assigned such an origin. Why is it not possible, on general grounds, that other ores should be gathered as are those of these two metals? In reply, it is manifest that we cannot rely entirely upon such general principles, as they are at present understood; but must resort to specific facts in connection with special cases. Few definite facts relating to this Mississippian area have been adduced in these recent papers which can stand as new reasons for believing in the deep origin of the ores, an explanation long since offered by Owen and Percival. Neither have we attempted to introduce positive demonstration in opposition to it. The question seems to be very much *in statu quo*, and, so long as it so remains, the old objections hold good and must be done away with before a change of opinion is warrantable. ARTHUR WINSLOW.